Life History and Abundance of Native Summer Steelhead in Lookingglass Creek, Oregon

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Abstract

The operation of the Lookingglass Hatchery adult trap and Lookingglass Creek rotary screw trap enables managers the opportunity to collect life history data across both juvenile and adult life stages for Lookingglass summer steelhead. Adult wild summer steelhead returning to the Lookingglass Hatchery trap averaged 188 during run years 2001-2011. Catches correlated well with wild “A” run catches at Lower Granite Dam, and sex ratios were dominated by females (approximately 60% of the catches each year). Mean FL fluctuated around 650 mm each year. The percentages of the catch considered as resident rainbow trout were usually less than 5% of the total catch and “large” fish (>78 cm FL) less than 4%. One-ocean and two-ocean returns were dominant with much lower numbers of three-ocean fish. Mean FL at age for males and females were similar. Arrival timing at the trap was usually early April for males and late April for females. For all but two years, the percentage of hatchery fish was 0-2% of the total catch. Detections at the Lookingglass Hatchery trap of adults tagged as outmigrating juveniles showed most returns passing Bonneville Dam in July-August and Lower Granite Dam in August-November prior to spring arrival at the Lookingglass Hatchery trap. Adults that were PIT tagged at Lower Granite Dam were usually tagged during the months of July-November prior to spring arrival at the Lookingglass Hatchery trap. A few fish of each group moved into freshwater in the spring and rapidly moved up the hydrosystem to Lookingglass Creek.

Juvenile outmigrants averaged 33,132 for 9 completed migration years from 2001-2011. Most juveniles out-migrants left during the spring season (mean 61%). Mean FL of outmigrants highest during March-April and September-October, at approximately 150 mm. Outmigrants were freshwater ages 0-3, but age 2 was dominant. Survival probabilities to Lower Granite Dam for fall groups ranged from 0.15-0.30, and from 0.30-0.90 for spring groups with most in the 0.50-0.70 range. Median arrival dates at Lower Granite Dam were similar for fall and spring groups and were usually during the first three weeks of May. Mean travel times were about 200 d for fall groups and 10-20 d for spring groups. Mean FL at tagging for fall groups detected the following spring were 150-160 mm FL, while mean FL at tagging for spring groups detected the same spring was slightly larger.

Abundances of both returning adults and juvenile outmigrants on average were about 3 times higher during 2001-2011 compared to data from the late 1960s. Adults arrived at the trap earlier in the late 1960s compared to 2001-2011. Small numbers of returning adults enter freshwater in the spring and rapidly move through the hydrosystem to Lookingglass Creek. Other life history attributes for both adults and juveniles are similar to those reported for the late 1960s for Lookingglass Creek and other populations in the region.

Lookingglass Creek is a significant part of the Upper Grande Ronde major population. Group designated for recovery planning. Catches of adults for the last decade have shown relatively little variability, indicating a stable population. Observed differences in adult returns and juvenile outmigrants between the late 1960s and current period may be
explained by differences in hydrosystem conditions, ocean productivity, or interspecific relationships.

**Introduction**

Many anadromous salmonid stocks in the Snake River Basin have declined to the point of extinction, principally due to construction and operation of hydroelectric facilities, overfishing, and the loss and degradation of critical spawning and rearing habitat (Nehlsen et al. 1991). The Grande Ronde River Basin once supported large populations of fall and spring Chinook (*O. tshawytscha*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon and summer steelhead (*O. mykiss*), and these populations have declined for similar reasons (U. S. Army Engineer District 1975, Nehlsen et al. 1991).

Hatcheries were built in Oregon, Washington and Idaho under the LSRCP to compensate for losses of summer steelhead due to the construction and operation of the four most downstream Snake River dams. Comanagers began augmenting populations in the Grande Ronde River using non-endemic Wallowa Hatchery stock in the early 1980s and Sport harvest was reopened in 1986 (Flesher et al. 2008). Natural summer steelhead populations continued to decline and Snake River summer steelhead were listed as threatened under the Endangered Species Act of 1973 on 18 August 1997. Comanagers discontinued off-station releases of Wallowa Hatchery stock summer steelhead into Catherine Creek (1998) and the upper Grande Ronde River (1999) due to high stray rates.

Little was known about native summer steelhead in the Grande Ronde Sub basin prior to the late 1960’s. Adult and juvenile bypass traps were installed near the current site of Lookingglass Hatchery in 1964, providing adult data for run years 1964-1974 (Burck 1993). McLean et al. (2001) summarized unpublished 1965-1974 return data for Lookingglass Creek summer steelhead collected by Wayne Burck (ODFW). Adult counts at the LH trap have also been compiled since 1997. The Lookingglass Creek summer steelhead population appears to be doing well in relatively undisturbed habitat with little influence from hatchery fish.

A juvenile bypass trap was operated on Lookingglass Creek and data for outmigrating *O. mykiss* were obtained for migration years 1966-1969 (Mullarkey 1971). We have captured juvenile *O. mykiss* in the Lookingglass Creek screw trap since 1992, and began PIT-tagging juvenile *O. mykiss* during the spring of 1999 to describe arrival timing and survival to Snake and Columbia River dams and other aspects of life history. A summary of life history information for several Grande Ronde Sub basin tributaries is contained in Anderson et al. (2011). Operations of the Lookingglass Creek adult and rotary screw traps were initiated to evaluate reintroduction of spring Chinook salmon above the Lookingglass Hatchery trap. The presence of these traps provided a good opportunity to obtain valuable life history information on ESA-listed summer steelhead.

The goal of this work is to provide basic life history data to guide management actions that aid in recovery of ESA-listed Snake River summer steelhead.
The preceding goal is consistent with the overall mission statement of the CTUIR Department of Natural Resources:

“To protect, restore, and enhance the First Foods; water, salmon, deer, cous, and huckleberry - for the perpetual cultural, economic, and sovereign benefit of the CTUIR. We will accomplish this utilizing traditional ecological and cultural knowledge and science to inform: 1) population and habitat management goals and actions; and 2) natural resource policies and regulatory mechanisms.”

The CTUIR DNR Fisheries Program mission statement is:

“To provide sustainable harvest opportunities for aquatic species of the first food order by protecting, conserving and restoring native aquatic populations and their habitats.”

Individual reports summarizing Lookingglass Creek summer steelhead life history data are available at http://www.fws.gov/lsnakecomplan/Reports/CTUIRreports.html

Study Area

The Lookingglass Creek watershed is in the Blue Mountains of northeast Oregon with the headwaters at an elevation of 1,484 m above sea level (Figure 2). Flow is to the southeast for 25 river km (rkm) through the Umatilla National Forest then through private land before entering the Grande Ronde River at rkm 137, at an elevation of 718 m above sea level. Lookingglass Creek has five major tributaries: Lost Creek, Summer Creek, Eagle Creek, Little Lookingglass Creek, and Jarboe Creek. Nearly all summer steelhead spawning occurs in Lookingglass Creek and Little Lookingglass Creek. Lookingglass Hatchery is located at approximately rkm 4.0 on Lookingglass Creek.

![Lookingglass Creek watershed](image)

Figure 1. Lookingglass Creek watershed.
Methods

Standard methods were used to collect summer steelhead and obtain data (Johnson et al. 2007). Adults were collected in the Lookingglass Hatchery weir and trap near the water intake (Figure 1). The weir consists of horizontal pickets over a concrete or rock apron for about 2/3 the width of the stream, with vertical removable metal pickets for the remainder. The fish trap consists of a steep pass fish way leading into a fyke, then into the fish holding area. The trap is installed about 1 March annually by ODFW Lookingglass Hatchery staff. The trap is normally checked Monday-Wednesday-Friday but more frequently if large numbers of fish are being trapped. The horizontal pickets also allow downstream passage of fish, as long as sufficient flow occurs. This means that some upstream migrants passed upstream are recaptured in the trap, and that post spawn fish are rarely recaptured. Week of capture was designated by the first day of the week (e.g. week of 1 January included 1-7 January). Hatchery-origin returns were euthanized and removed from the stream. Wild adults were transported about 0.6 rkm upstream and released.

Figure 2. Lookingglass Hatchery adult fish trap located at rkm 4.0 on Lookingglass Creek near the hatchery water intake.
Data collected for each trapped fish included fork length, sex, and any external (fin clips, radio or other tags) and internal (PIT tags) marks or tags. Fish were anesthetized in MS222 until 2010, thereafter, fish were handled “hot” (without anesthetic). Tissues collected included scales for age determination and opercle punches for genetics analysis (Narum et al. 2006). Data and tissues were collected from all fish, including those that were less than 50 cm FL. Fish less than 50 cm (i.e. 20 in.) are assumed to be resident *O. mykiss* and not anadromous returns. Sex was based on external characteristics (snout, belly and vent appearance). Fish were scanned using a Digital Angel FS2001F PIT tag reader. Scales were taken from the standard area just above the lateral line on a diagonal from the posterior end of the dorsal fin to the anterior end of the anal fin. Scales were placed in envelopes, dried, and hot-pressed onto cellulose acetate for later examination under a microfiche reader. Freshwater and saltwater annuli were determined using characteristics by Mosher (1969).

Measures used to describe adult life history included escapement, sex ratio, size composition, age composition (ocean), fork length-at-age, arrival timing at trap, % hatchery-origin, and detections at the trap of PIT-tagged returns.

Figure 3. Summer steelhead sampling at the Lookingglass Hatchery trap.

We collected outmigrating juvenile *O. mykiss* using the 1.52 m diameter rotary screw trap at rkm 4.0 on Lookingglass Creek near Lookingglass Hatchery. The screw trap was operated continuously during 2007-2008 except for brief periods during the spring freshet, when flows were low and temperatures high (July-August), and when iced up in winter. The trap was usually checked 3 times a week or more frequently if catches or flows were high. All *O. mykiss* were enumerated, examined for external marks, scanned with a PIT tag reader, measured (nearest mm FL), and weighed (nearest 0.1 g). First-time captures in good condition (no injuries or obvious disease) were PIT-tagged using standard methods (PIT Tag Steering Committee 1999). In most years, a lower length limit of 80 mm FL was used. Some fish received a partial fin clip (lower caudal) instead
of PIT tag and were released above the trap to supplement the PIT-tagged sample for trap efficiency estimates. Recaptures of fin-clipped fish were apportioned to the various recapture periods using the percentages observed for PIT-tagged recaptures. All newly-PIT tagged and clipped outmigrants were released about 100 m above the screw trap; recaptures were released about 0.3 rkm below the screw trap.

Figure 4. Lookingglass Creek rotary screw trap (1.5 m diameter) at rkm 4.0, just below the Lookingglass Hatchery adult weir and trap.

Figure 5. PIT-tagging outmigrating Lookingglass Creek juvenile *O. mykiss*. 
We used DARR 2.0 (Bjorkstedt 2008) to estimate the numbers of outmigrants. DARR 2.0 uses mark-recapture data stratified by time period, pooling those with similar capture probabilities. We used the “one trap” and “no prior” pooling of strata options. *O. mykiss* juveniles (all wild, no hatchery releases) out migrate from Lookingglass Creek during the entire year, with peaks during the spring (usually March-May) and fall (usually September and October). The conventional migration year was used (1 July of year \(x\) through 30 June of year \(x+1\)). Fall groups were caught from 1 July-31 December of each year and spring groups from 1 January-30 June.

FL and weight at PIT-tagging, travel time, survival and capture probability to Lower Granite Dam data were obtained from the PIT tag database maintained by the Pacific States Marine Fisheries Commission at http://www.ptagis.org/. We estimated arrival timing to Lower Granite Dam using daily PIT tag detections expanded for spill using flow data from the U. S. Army Corps of Engineers Portland District website (http://www.nwd-wc.usace.army.mil/perl/dataquery.pl?id:LWG) and calculating a daily expansion factor \([(\text{Powerhouse Outflow} + \text{Spill}) / \text{Powerhouse Outflow}]\). Median arrival date at Lower Granite Dam for each group was obtained using the date of 50% expanded daily detections. Survival, capture probabilities, and travel time to Lower Granite Dam were estimated using PitPro (Westhagen and Skalski 2008). We used the standard configuration, excluded the *.rcp file and included the mortality file. Observation sites, in downstream order, were Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, Ice Harbor Dam, McNary Dam, John Day Dam, Bonneville Dam, and the Estuary Towed Array (Juvenile). Survival, capture probabilities, and travel time were estimated for only those outmigrants detected during the year following tagging. Outmigrants leave Lookingglass Creek at a wide range of sizes and may be detected as out-migrating through the hydro system during several years, spending time in the Grande Ronde River below Lookingglass Creek to add growth before continuing their outmigration.

Measures used to describe juvenile life history included abundance, size at capture, freshwater age, survival probability to Lower Granite Dam, hydrosystem detection of outmigrants <115 mm FL, arrival date at and travel time to Lower Granite Dam and size at detection in the hydrosystem.

**Results and Discussion**

The average trap catch was nearly 3 times higher for the 2001-2011 period and was also less variable than during the 1965-1974 period (Figure 6). The Lookingglass Hatchery trap catches correlated well with the wild “A” run counts at Lower Granite Dam (Figure 7). The mean sex ratios from 2001 to 2011 showed 60% of adult returns were females (Figure 8). The mean FL of returning fish varied around 650, and was more variable during run years 2002-2006 (Figure 9). The percentage of fish <50 cm FL (considered resident rainbow trout) was variable, but usually less than 5% (Figure 10). With the exception of 2003, “large” returns were less than 4% of the total. The ocean age composition of fish aged was primarily ages 1 and 2, with age 1 fish dominant in 5 of 8 years (Figure 11). Age 3 fish were a minor component of the run each year, present in
only 4 run years. Mean FL at ocean age for males and females showed were similar for the sexes, but were highly variable within an age group (Figures 12-13). The median weeks of arrival at the trap were earlier for males than females (Table 1). Median week of arrival timing at the trap from Burck’s (unpublished data) was most commonly in mid-May (McLean et al. 2001). For all but two years, the percentage of hatchery-origin fish (ad-clipped) fluctuated from zero to slightly over 2% (Figure 14). The run year with the highest percentage (2011) was also the year of highest escapement for wild fish. Ad-clipped fish have normally been euthanized at the trap, but in 2010, some were released below the trap to allow anglers to catch them.

![Graph](image)

Figure 6. Trap catches of summer steelhead, run years 1965-1974 (Mullarkey 1972) and 2001-2011.
Figure 7. Comparison of summer steelhead escapement at Lookingglass Creek and Lower Granite Dam.

Figure 8. Sex ratios (% female) of returning summer steelhead captured at the Lookingglass Hatchery trap (dashed line is average for run years 2001-2011).
Figure 9. Mean FL of returning summer steelhead captured at the Lookingglass Hatchery trap.

Figure 10. Percent “rainbow trout” (RBT) and “large” fish (≥78 cm FL) for returning summer steelhead captured at the Lookingglass Hatchery trap.
Figure 11. Age composition of returning summer steelhead captured at the Lookingglass Hatchery trap.

Figure 12. FL at age of returning female summer steelhead captured at the Lookingglass Hatchery trap.
Figure 13. FL at age of returning male summer steelhead captured at the Lookingglass Hatchery trap.

Table 1. Median arrival week (April 2, 9, 16, 23, or 30) at the Lookingglass Hatchery adult trap for returning summer steelhead 500 mm FL or greater.

<table>
<thead>
<tr>
<th>Run Year</th>
<th>Males</th>
<th>Females</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week</td>
<td>N</td>
<td>Week</td>
</tr>
<tr>
<td>2001</td>
<td>23</td>
<td>42</td>
<td>23</td>
</tr>
<tr>
<td>2002</td>
<td>9</td>
<td>99</td>
<td>23</td>
</tr>
<tr>
<td>2003</td>
<td>2</td>
<td>56</td>
<td>9</td>
</tr>
<tr>
<td>2004</td>
<td>9</td>
<td>57</td>
<td>23</td>
</tr>
<tr>
<td>2005</td>
<td>9</td>
<td>75</td>
<td>16</td>
</tr>
<tr>
<td>2006</td>
<td>9</td>
<td>71</td>
<td>9</td>
</tr>
<tr>
<td>2007</td>
<td>23</td>
<td>47</td>
<td>23</td>
</tr>
<tr>
<td>2008</td>
<td>23</td>
<td>53</td>
<td>30</td>
</tr>
<tr>
<td>2009</td>
<td>9</td>
<td>85</td>
<td>16</td>
</tr>
<tr>
<td>2010</td>
<td>16</td>
<td>128</td>
<td>16</td>
</tr>
<tr>
<td>2011</td>
<td>16</td>
<td>83</td>
<td>30</td>
</tr>
</tbody>
</table>
Figure 14. Percent ad-clipped (hatchery-origin) of returning summer steelhead captured at the Lookingglass Hatchery trap.

PIT tag detections of adults at the Lookingglass Hatchery trap totaled 64 during run years 2008-2011, and included both fish tagged as outmigrating juveniles and returning adults (Tables 2-3). In run year 2010, there were 11 adult detections at the Lookingglass Hatchery trap of fish tagged and released as outmigrants. Four were tagged and released from the Lookingglass Creek screw trap, 5 at Lower Granite Dam, 1 at the Tucannon River screw trap, and 1 at the South Fork John Day screw trap. One adult detected at the Lookingglass Hatchery Trap in 2008 was tagged and released at Priest Rapids Dam. Detections at Bonneville Dam occurred in July or August, preceding arrival the following spring at the Lookingglass Hatchery trap. Detections at Lower Granite Dam were usually in September-October (the fall previous to capture at the Lookingglass Hatchery trap, but 2 were in April and March).

Table 2. Adult return history of summer steelhead PIT-tagged as juvenile outmigrants from Lookingglass Creek.

<table>
<thead>
<tr>
<th>Run Year (N)</th>
<th>Months of Detection at Bonneville Dam</th>
<th>Months of Detection at Lower Granite Dam</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008 (7*)</td>
<td>July-3, August-3</td>
<td>September-1, October-4, April (‘08)-1</td>
</tr>
<tr>
<td>2009 (8)</td>
<td>July-7, August-1</td>
<td>July-1, August-1, September-3,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>October-1, November-1, March (‘09)-1</td>
</tr>
<tr>
<td>2010 (11*)</td>
<td>July-5, August-3, October-1</td>
<td>August-2, September-2, October-3,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>November-2</td>
</tr>
<tr>
<td>2011 (5)</td>
<td>July-5</td>
<td>July-3, October-1, November-1</td>
</tr>
</tbody>
</table>
Substantial numbers are being PIT-tagged under the ISEMP project, with more instream arrays being established throughout the Columbia River Basin. (ODFW has operated one in the Lookingglass Hatchery fish ladder). Recaptured adults in the Lookingglass Hatchery trap were tagged at Lower Granite Dam primarily during July-November preceding arrival at Lookingglass Creek the following spring. However, there were 2 adults tagged at Lower Granite Dam in the in the spring that were recaptured at Lookingglass Creek shortly afterward.

Table 3. Return history of summer steelhead PIT-tagged as adults at Lower Granite Dam.

<table>
<thead>
<tr>
<th>Run Year</th>
<th>N</th>
<th>Month of Tagging</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>14</td>
<td>September-6, October-4, November-2, March (‘10)-1</td>
</tr>
<tr>
<td>2011</td>
<td>17</td>
<td>July-1, August-2, September-8, October-4, November-1, March (‘11)-1</td>
</tr>
</tbody>
</table>

The estimated outmigrants by migration year averaged 33,132 for years when both fall and spring estimates were available, or slightly over 3 times the average from the late 1960s. Mullarkey (1971) reported estimates ranging from 7,727-13,261 (mean 10,914). Spring outmigrants ranged from 32-91% of the total outmigrants for migration years 2002-2008 and 2010-2011, and averaged 61%. Mullarkey (1971) reported that spring was the most important season for outmigration, with the lowest numbers in August and December. Mullarkey (1971) observed peaks in the percentages of fish less than 130 mm in length in January and June, with a trough in April. Similar pattern over four migration years.

Mean FL of first-time captures at the Lookingglass Creek screw trap showed peaks in March-April and September-October, corresponding to peaks in outmigration (Figure 16). The age composition of the fall group of outmigrants was dominated by age 2 fish, with much smaller numbers of ages 0, 1, and 3 (Figure 17). Spring groups had higher numbers of ages 0 and 1 (Figure 18). Mullarkey (1971) observed 78-93% of outmigrants were age 1+ and 2+ fish. Zero aged fish were variable at 0.7-12.8% and 3+ fish were 0-13.9%.

Survival probabilities of fall groups were variable, fluctuating around 0.15-0.30 for all migration years except 2003 (Figure 19). Survival probabilities of spring groups (≥115 mm FL) were higher and more variable than fall groups (Figure 20). The largest numbers of outmigrants tagged at FL less than 115 mm FL are detected in the hydrosystem one year later, with much smaller numbers detected during the same migration year of tagging and two years after tagging (Figure 21). Median arrival dates at Lower Granite Dam were similar for both spring and fall groups (Figure 22). Mean travel times for fall groups fluctuated around 200 d, and for spring groups, approximately 10-20 d (Figure 23). Mean FL at tagging for fall groups detected the following spring were 150-160 mm FL (Figure 24), while mean FL at tagging for spring groups detected the same spring appeared to be slightly larger (Figure 25).
Figure 15. Lookingglass Creek *O. mykiss* outmigrants by migration year.

Figure 16. Mean FL (mm) of outmigrating Lookingglass Creek *O. mykiss*.
Figure 17. Freshwater age composition of spring group outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, migration years 2008-2010.

Figure 18. Freshwater age composition of spring group outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, migration years 2008-2010.
Figure 19. Survival probabilities to Lower Granite Dam of the fall groups (all sizes) of outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, PIT-tagged and released.

Figure 20. Survival probabilities to Lower Granite Dam of the spring groups (≥115 mm FL) of outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, PIT-tagged and released.
Figure 21. Hydroystem detections of small (<115 mm FL) outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, PIT-tagged and released.

Figure 22. Median arrival dates at Lower Granite Dam for fall and spring groups of the same migration year of outmigrating *O. mykiss* collected at the Lookingglass Creek rotary screw trap, PIT-tagged and released.
Figure 23. Mean travel time (d) from the Lookingglass Creek rotary screw trap to Lower Granite Dam for fall and spring groups in the same migration year of outmigrating *O. mykiss*.

Figure 24. Mean FL (mm) at PIT-tagging of outmigrants from fall groups detected at in the Columbia and Snake Rivers hydrosystem.
Figure 25. Mean FL (mm) at PIT-tagging of outmigrants from spring groups detected at the Columbia and Snake Rivers hydrosystem.

Summary

Adult abundance showed a 3-fold increase from 1965 to 1974 time period compared to 2001-2011, and has been relatively stable the past 11 years. Arrival timing at the Lookingglass Hatchery trap has been later during the 2001-2011 period compared to 1965-1974. Life history attributes of adults collected during 2001-2011 have shown variability from year to year but are consistent with the limited contemporary data available for other populations in the region. Catches were dominated by females and almost all fish were ocean ages 1 and 2. PIT tag information showed migration patterns consistent with previous studies, although small numbers of returning fish entered freshwater in the spring rather than the previous fall, and rapidly moved upstream.

Outmigrant totals during 2001-2011, similar to adult catches, were on average, 3 times the average reported during the late 1960s by Mullarkey (1971). Size, freshwater age composition, and seasonal distribution of outmigration were all similar to observations of Mullarkey (1971). For fish leaving Lookingglass Creek the same year, survival was lower for fall outmigrants than spring. Outmigrants less than 115 mm FL were usually detected a year later than larger fish. Arrival timing at Lower Granite Dam was similar for fall and spring outmigrants during the same migration year.

Recovery Implications

Lookingglass Creek summer steelhead within the Upper Grande Ronde population
Upper Grande Ronde is one of 4 populations within the Grande Ronde MPG (others Lower Grande Ronde, Wallowa R., Joseph Creek). The Minimum Abundance Threshold is 1,500 for Upper Grande Ronde population; therefore Lookingglass Creek is a significant part of this population. Catches of adults for the last decade have shown relatively little variability, indicating a stable population. This has occurred despite the influence of dams, that has perhaps been mitigated by the good spawning and nursery habitat that exists in Lookingglass Creek.

The differences in both adult returns and juvenile outmigrants between the late 1960s and current period may be explained by differences in hydro system conditions, ocean productivity, or perhaps interspecific relationships. The numbers of juvenile outmigrants have declined during the same period when the numbers of adult spring Chinook spawners above the hatchery weir have increased. The numbers of adult summer steelhead returning, also in the current era, have been relatively stable in the face of much higher variability in juvenile *O. mykiss* out-migrant abundance.

**References**


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